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TECHNICAL REPORT
69-65-FL

DEVELOPMENT OF RADIATION-STERILIZED FISH PRODUCTS

by

Melvin E. Waters & Mary H. Thompson

U. S. Dept. of the Interior,
Fish & Wildlife Service,
Bureau of Commercial Fisheries,
Pascagoula, Mississippi

April 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory
FL-79

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DEVELOPMENT OF RADIATION-STERILIZED FISH PRODUCTS

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Pascagoula, Mississippi

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FOREWORD

The availability of shelf-stable, highly acceptable seafood items for use in military feeding systems is considered a necessity. Radiation processing, or "cold" sterilization as it is frequently called, has the potentiality of yielding products that have good military utility, good storage stability, and good acceptability. Therefore, research to develop process criteria that can be used to produce irradiation sterilized seafoods is under way.

The work covered in this report was a cooperative effort performed by the U. S. Department of the Interior, Fish and Wild Life Service, Bureau of Commercial Fisheries, Pascagoula Fishery Station, Pascagoula, Mississippi under Project No. 1J062110A033, Radiation Preservation of Food, Basic Food Irradiation Research during the period 25 August 1967 to 25 August 1968 and the U. S. Army Natick Laboratories. It represents an investigation of the effects of a variety of pre- and post-irradiation process variables on the acceptability of radiation sterilized fish items. These variables include such factors as type and quality of the raw material, enzyme inactivation techniques, and the use of selected additives such as spices and seasonings.

Mr. Melvin E. Waters was the Project Officer and official investigator and Mrs. Mary H. Thompson the principal collaborator for the Pascagoula Fishery Station. The U. S. Army Natick Laboratories Project Officer was Dr. F. Heiligman and the Alternate Project Officer was Dr. Wierbicki, both of the Food Laboratory.

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ABSTRACT

Procedures have been developed for producing several different irradiation-sterilized (4.5 - 5.6 Mrad at -30°C ±10°C) fish items, using salmon and tuna as basic ingredients, which were scored as acceptable shortly after irradiation. Breading and additional cooking after irradiation resulted in a decrease in irradiation odor and flavor. Addition of hickory smoke also tended to reduce irradiation induced odor and flavor changes. Irradiation caused a bleaching of typical salmon color in the salmon cakes but did not effect the color in the tuna cakes. The texture of the tuna appeared to be more affected by the irradiation treatment than the texture in salmon, with a tendency towards dryness in the tuna.

No storage stability studies were done.

INTRODUCTION

The development of acceptable radiosterilized products utilizing tuna and salmon has not been fully explored. Several attempts have been made, principally through screening procedures, to determine if these species were adaptable to irradiation preservation. Several other species of fish have been determined suitable for irradiation sterilization; however, these species are relatively low in oil content. On the other hand, these species present problems not encountered with tuna and salmon; namely, browning and structural breakdown of the flesh.

Tuna and salmon are two of the most highly prized fishes commanding good prices and good consumer acceptance. Additional products or new products and processing techniques would increase the consumption of these fishes. The military does not presently have convenience items prepared from fish such as tuna or salmon loaf, patties, or sausage which can be utilized by the field soldier.

The objectives of this study are to develop products suitable for irradiation sterilization and to determine consumer reactions and acceptance to these products.

EXPERIMENTAL METHODS

Product Development.

Salmon and tuna were used as the basic fishery material with several variations in the type of product being developed. The fish were caught, immediately frozen, glazed, and shipped to Pascagoula for storage at -5°F. For products other than steaks, the fish were steamed 30 seconds, and the skin, bone, and dark meat removed.

Breaded precooked steaks. Salmon was utilized in the development of this product. Tuna does not lend itself very well to breaded steaks. Salmon steaks were prepared using various breading formulas. The breading and batter combination that proved to be the best was a recipe developed by Modern Maid Food Products, Inc. This material produced an excellent product relative to color, adhesion of the coating, and final texture of the product. Enzyme inactivation was accomplished by holding the steaks for 3 to 4 minutes (depending upon thickness of steaks) in vegetable oil heated to 360°F. An internal temperature of 170°F was recorded using a Leeds and Northrup potentiometer and bayonet-type thermocouples. The oil was treated with antioxidants by the manufacturer and changed frequently to minimize adding rancid flavors to the products. The precooked steaks were placed in cans with paper separators and charcoal packets, and sealed under vacuum. The product was frozen to -5°F

and divided into three portions. One portion was thawed and served to a taste panel; a second portion sent to the U. S. Army Natick Laboratories to be irradiated; and the third retained as control.

Previous experimentation has shown some disagreement with the method of preparing the fish prior to breading, cooking, freezing, thawing, and reheating. An extensive experiment was conducted to determine consumer preference for (1) thickness of steaks; (2) presence of bone and skin; (3) texture and integrity of the steaks after thawing and reheating; and (4) method of reheating the steaks (i.e., heating in oil at 360°F momentarily or heating in an open oven for a predetermined period of time). All variables were prepared as described above and served to a consumer taste panel.

Broiled steaks. A second method of enzyme inactivation was tested (using salmon only). Steaks were heated in an oven until the center temperature reached 170°F. An unsightly curd formation, due to protein coagulation, resulted; therefore, additional methods were researched. Raw steaks were treated in various solutions for varying lengths of time. Solutions were 1, 3, and 5% NaCl, and 3, 5, and 10% tartaric acid. Steaks were treated for 10 minutes, 1/2 and 1 hour periods in each solution. The steaks were broiled, as described above, and re-evaluated. Because of the problems encountered, the product was deemed unsuitable for irradiation purposes and consequently no further work was performed.

Fish cakes. Tuna and salmon were used to prepare patties using a formula for cod fish cakes. The formula is as follows:

Corn meal, white	5.0%
Gelatin*	1.5%
Salt	1.0%
Monosodium glutamate	0.15%
Water	10.0%

A second formula** was also used consisting of:

Fish flakes	100 lbs
Fish cake seasoning No. 59 (Griffith)	3 lbs
Dehydrated chopped onion	3 lbs
Instant mashed potatoes	7 lbs
Water (cold)	43 lbs

Appropriate amounts of liquid smoke were added to each formula for additional products

* Viscomix, Swift & Company, Chicago, Illinois
** Griffith Laboratories, Chicago, Illinois

The products were prepared by first removing the edible portions of the fish and putting the material through a meat grinder equipped with a plate having 1/4-inch holes.

The flesh was mixed thoroughly with the ingredients of each formula and stuffed into fibrous casings. The "tubes" were then placed in a water bath and heated to an internal temperature of 170°F. The product was then cooled to 37°F, sliced, and placed in cans. The cans were sealed under vacuum and frozen to -5°F. After 7 days frozen storage a portion was irradiated at 4.5 Mrads and -30°C. A portion was retained as control. For serving to the taste panel, cakes were breaded and fried in oil at 360°F.

Fish loaf. Salmon and tuna loaf-type products were prepared. Ten different formulations were tested including one containing tomato sauce. Each product was panel-tested and refined until an acceptable product was produced. The two selected formulas contained:

Formula No. 1

50 pounds tuna or salmon
3-3/4 cups instant potatoes
5 cups chopped onion
1 cup salt
3/8 cup pepper
1/3 cup garlic salt
20 cups water

Formula No. 2

30 pounds tuna or salmon
36 tablespoons instant potatoes
12 tablespoons salt
4 tablespoons pepper
12 cups water
3 cups chopped onion

Sauce

42 ounces tomato paste
52-1/2 ounces tomato sauce
7 bay leaves
7 teaspoons onion powder
3-1/2 teaspoons garlic salt
7 teaspoons salt
3-1/2 teaspoons pepper
7/8 teaspoon oregano
7-1/2 cups water

After an acceptable product was developed, a large batch was prepared for irradiation. The raw flesh was ground, mixed with the ingredients, and stuffed into fibrous casings. The loaf was enzyme inactivated in a water bath as previously described. The fibrous encased loaf was cut into sections after heating and cooling, and placed into cans. Sauce was prepared separately, placed in polyethylene bags, and put into the cans with the loaf. The cans were sealed under vacuum and frozen. Each lot, i.e., salmon and tuna with and without sauce, was divided and one-half irradiated; the second half held as control. After irradiation, the products were toxin-tested and served to a taste panel.

Enzyme Inactivation.

Enzyme inactivation is a vital step in the irradiation sterilization of all products. Since the irradiation process does not accomplish this task, the best method is the use of heat. Heating should not exceed the point at which the enzymes are destroyed. For processing fish, this temperature is in the range of 150-170°F. Several methods were tested to inactivate enzymes in products developed at this laboratory. Where appropriate, the following methods were employed:

1. Heating in steam (212°F).
2. Heating in microwave oven.
3. Cooking in oil at 360°F.
4. Broiling and baking in an open air oven.
5. Sealing in plastic bags and heating in a boiling water bath.

Coatings.

Several coating materials were tested to find one which would prevent moisture loss during the cooking process. Due to extended cooking times necessary to accomplish enzyme inactivation, the products often became dry and fibrous. Food grade coating materials used were:

1. Methylcellulose
2. Hydroxypropyl methylcellulose, Type 90 HG
3. Hydroxypropyl methylcellulose, Type 65 HG
4. Hydroxypropyl methylcellulose, Type 65 HG, 400 CPS
5. Hydroxypropyl cellulose
6. Alginate-monodextrin-dextrose $CaCl_2$ mixture with carboxymethylcellulose as a thickening agent.
7. Fish slurry containing 2% methylcellulose.

All costings were applied to the raw fish prior to the breading operation with the exception of methylcellulose which was incorporated in the batter solution.

Product Acceptance (non-irradiated).

Each product developed was first evaluated by a technical panel for suggested improvements. Finally, a consumer-type panel, consisting of 20 to 25 participants, rated the products on a 9-point hedonic scale. On the basis of these results, the product was determined acceptable or unacceptable.

Irradiation of Products.

Several cans of fish were irradiated at various doses to properly train a taste panel in recognizing irradiation flavors and odors. The irradiation was carried out at -30°C with doses of 4.5, 3.0, 2.5, and 1.0 Mrads being applied. The panel was served the irradiated fish three different times and told of the doses given each.

Products considered acceptable before irradiation were shipped frozen to the U.S. Army Natick Laboratories for irradiation at -30°C and 4.5 Mrads (minimum dose). The products were returned to Pascagoula frozen, and held frozen until rated by the taste panel.

All irradiated products were toxin-tested using accepted procedures before serving to the taste panel. The procedure consists of injecting mice with an extract fish (1:5 fish:buffer) and observing the mice 96 hours. Approximately 120 mice were utilized resulting in no deaths due to the injections. Only after negative results were obtained during toxin testing were the products served to the panel.

Taste Panel Evaluation (irradiated product).

Irradiated products were first evaluated by a trained test panel. If acceptable to this highly critical group, the products were then evaluated by a consumer-type panel. The results of the consumer panel evaluation of irradiated products and comparable non-irradiated frozen controls are shown in the following Table. A score of 5.5 or above was considered acceptable. Comments on flavor and odors were solicited. Each member was asked to identify flavor and odor using descriptive terms.

Average Hedonic Ratings for Irradiated and Non-irradiated Fishery Products Developed at the Pascagoula Fishery Station

Product	Irradiated	Non-irradiated
Salmon loaf without sauce	6.31	6.42
Salmon loaf with added sauce	6.10	6.05
Tuna loaf without sauce	6.16	6.21
Tuna loaf with added sauce	*5.26	--
Smoked tuna cakes	7.44	7.56
Tuna cakes	7.44	6.94
Smoked salmon cakes	7.38	7.85
Salmon cakes	7.50	7.88
Breaded precooked salmon steaks	5.93	6.42
Precooked (steamed) salmon steaks	--	--

* Considered unacceptable.

RESULTS AND DISCUSSION

Breaded Precooked Steaks:

A batter-breading combination manufactured by Modern Maid Food Products, Inc. produced the best appearance on precooked steaks. Four minutes heating 3/4-inch steaks produced a golden brown color and yet resulted in the required 170°F internal temperature. The 1/2-inch steaks required 3 minutes to produce the same results. The taste panel preferred 3/4-inch steaks over the 1/2-inch thickness. They also preferred boneless, skinless steak; however, these steaks tended to fall apart upon cooking. Next in order of preference by the taste panel was the skinless steak with bone intact.

Taste panel scores were somewhat lower after freezing the steaks due primarily to the reheating method. It was shown, however, that reheating in oil at 360°F for approximately 1 minute produced a more acceptable product than heating the steaks in an open-air oven for 30 minutes at 375°F. The irradiated steaks were scored 5.6 by the consumer panel.

The steaks were coated before cooking to prevent moisture loss. Of the several coatings used, hydroxypropyl methylcellulose retained the most moisture. This chemical probably could best be incorporated in the batter formula. Addition of the coating did not affect the organoleptic scores.

Broiled Steaks.

Several methods of heat inactivation were tried only to find that none of the results were acceptable to the panel. The steaks always appeared with an unsightly substance (coagulated protein) leached (or cooked) from the steaks. All conceivable methods for prevention of the curd were tried, including treatment with acids without success. Development of an acceptable irradiated broiled steak was abandoned.

Fish Cakes.

Several formulations were used to prepare fish cakes. The most acceptable consists of corn meal, gelatin, water, and seasoning. Irradiated tuna and salmon cakes were both acceptable; salmon scored 7.50, tuna scored 7.44. Liquid smoke was added to each fish product; salmon scored 7.38 while tuna scored 7.44. Although the scores do not show it, the smoke flavor appears to mask the irradiated flavors and odors.

The formula proposed by Griffith Laboratories, even after several modifications, was not acceptable. The taste panel would not score this product above 5.5.

Fish Loaf.

The following scores were received for the irradiated tuna and salmon loafs:

Tuna loaf without sauce.....	6.16
Tuna loaf with sauce added.....	5.26
Salmon loaf without sauce.....	6.31
Salmon loaf with sauce added.....	6.10

(See Table - Page 6).

Only the tuna loaf with sauce added was scored unacceptable by the panel. The irradiated flavors and odors were predominate in this product.

Enzyme Inactivation.

Heating salmon steaks to inactivate autolytic enzymes presented somewhat of a problem. Either broiling or baking the steaks in an open-air oven caused coagulated protein to deposit on the surface. This unsightly white precipitation had to be removed for acceptance by the panel; however, it could not be removed completely.

Heating the steaks in steam proved equally unsuitable. The same condition existed. Steaks were put in polyethylene bags and held in boiling water until the internal temperature reached 170°F. Again, the protein leached out of the steaks.

A final method was tried using microwave heating. The steaks were unevenly heated; however, that portion heated also showed a curd formation. Prolonged heating produced a "burned" effect and was equally unacceptable. The development of salmon steaks as an irradiated product was abandoned.

Heating breaded steaks and fish cakes in oil at 360°F produced a very good product. Several temperatures and exposure times were tried. Corn oil containing BHT* or BHA** was used for this purpose to eliminate rancidity as much as possible. Filtering out bread and fish particles between cooking of different lots reduced rancid flavors to a great degree.

Heating fish in a fibrous casing to 170°F presented some problems. Occasionally the casing would rupture and water would escape from the loaf. Coagulation of the protein did not present any problems. The leaching of water and gelatin to the outside of the loaf was also a problem, although this was prevented by continuous turning.

Evaluation of Irradiated Products (U.S. Army Natick Laboratories).

Portions of each irradiated product, plus a comparable non-irradiated frozen control, were sent to the U.S. Army Natick Laboratories for evaluation. Both the salmon cakes and tuna cakes were rated in the acceptable range. The salmon products were preferred to the tuna products; and products without liquid smoke were preferred to those with liquid smoke.

Overall Observations.

Radiosterilized precooked salmon steaks are acceptable to a consumer-type taste panel despite slight irradiation flavors and odors. Irradiated breaded precooked salmon steaks are more acceptable when heated in oil than in an open-air oven. Moisture barriers may be used as a constituent of the batter. Coatings did not appreciably prevent moisture loss or affect the panel scores.

Irradiated tuna and salmon fish cakes were the most acceptable of all products developed. The cakes were breaded and cooked after irradiation which resulted in a decrease in irradiated flavors and odors. The

* BHT - butylated hydroxytoluene
** BHA - butylated hydroxyanisole

addition of hickory smoke further masked irradiation flavors. Irradiated salmon cakes were lighter in color than the non-irradiated counterpart. The color of the tuna cakes was not affected by irradiation and the flavor and odor not changed appreciably when compared to the change occurring in salmon cakes. The color of both products, however, was not considered a factor by the panel. Texture was affected more in tuna than in salmon products; there being a tendency toward dryness in tuna.

Unbreaded salmon steaks were unacceptable when heat-treated to inactivate the enzymes. Three-quarter inch steaks were preferred over 1/2-inch steaks because the steaks remained intact and contained more moisture; consequently, they were better textured.

Tuna and salmon loaves containing condiments also offer a real possibility as irradiated products.

RECOMMENDATIONS

Irradiated tuna and salmon loaves as well as tuna and salmon cakes are acceptable products. Research should be continued to determine their acceptability under different conditions of storage. Other species of fish, such as bonita, spanish mackerel, and mullet should be researched to determine their suitability as an irradiated products either as fillets, cakes, loaves, or convenience items.

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13. ABSTRACT

Procedures have been developed for producing several different irradiation-sterilized (4.5 - 5.6 Mrad at -30°C ≠10°C) fish items, using salmon and tuna as basic ingredients, which were scored as acceptable shortly after irradiation. Breading and additional cooking after irradiation resulted in a decrease in irradiation odor and flavor. Addition of hickory smoke also tended to reduce irradiation induced odor and flavor changes. Irradiation caused a bleaching of typical salmon color in the salmon cakes but did not effect the color in the tuna cakes. The texture of the tuna appeared to be more affected by the irradiation treatment than the texture in salmon, with a tendency towards dryness in the tuna.

No storage stability studies were done.

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